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TRANSMITTAL LETTER (General - Patent Pending)	Docket No. BUR920010011US1 (14331)

In Re Application Of: **Jeffrey B. Johnson, et al.**

Application No.	Filing Date	Examiner	Customer No.	Group Art Unit	Confirmation No.
09/866,319	May 25, 2001	Dana Farahani	23389	2814	5556

Title: **PROCESS FOR MAKING A HIGH VOLTAGE NPN BIPOLAR DEVICE WITH IMPROVED AC PERFORMANCE**

COMMISSIONER FOR PATENTS:

Transmitted herewith is: **APPELLANTS' REPLY BRIEF**

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Dated: **September 14, 2004**

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Jeffrey B. Johnson, et al.

Examiner: Dana Farahani

Serial No: 09/866,319

Art Unit: 2814

Filed: May 25, 2001

Docket: BUR920010011US1 (14331)

For: PROCESS FOR MAKING A HIGH VOLTAGE NPN BIPOLAR DEVICE WITH IMPROVED AC PERFORMANCE

Dated: September 14, 2004

Confirmation No: 5556

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPELLANTS' REPLY BRIEF

Sirs:

In response to the Examiner's Answer dated July 14, 204, Appellants submit the following remarks for consideration and entry of record in the above-identified case. Appellants have included an appendix with this submission which includes a listing of the claims on Appeal.

CERTIFICATE OF MAILING UNDER 37 C.F.R. §1.8(a)

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REMARKS

In the Examiner's Answer dated July 14, 2003, the Examiner maintained the rejection of Claims 2, 6, 8, 12, 13, 15, 16 19, 23, and 45, relating to Appellants' method, and Claims 24, 25, 28, 30, 32, 34-36, 39-41, and 43, relating to Appellants' structure. Appellants respectfully disagree and are submitting the present Reply Brief in order to clarify that Marty, et al. does not disclose Appellants' claimed n-type dopant region having a vertical width sufficiently narrow to avoid lower collector-base breakdown voltage and having a dopant concentration sufficiently high to resist base widening, as recited in Claims 24 and 35. In the Examiner's Answer, the Examiner alleges that the selectively implanted collector (SIC) region disclosed in Marty, et al. meets the limitation of Appellants' n-type dopant region having a vertical width sufficiently narrow to avoid lower collector-base breakdown voltage and having a dopant concentration sufficiently high to resist base widening.

Referring to Page 12 of the Examiner's Answer, the Examiner first argues that the SIC region illustrated in FIG. 6 of the Marty, et al. disclosure does not contact the base region of the device and therefore meets the limitation of Appellants' claimed n-type dopant region that has a vertical width sufficiently narrow to avoid reducing the collector base breakdown voltage of the device when forward biased. Referring now to Page 13, the Examiner then disputes that the differences in processing between Appellants' claimed n-type region and the Marty, et al. SIC region necessarily result in different dopant profiles of the n-type dopant region and the SIC region and instead relies on the acronym Selectively Implanted Collector (SIC) to argue that the depth of the SIC region may be controlled. Finally, the Examiner argues that it would be obvious to adjust the height of the SIC region disclosed in Marty, et al. to reduce collector resistance. Appellants' disagree with each of the Examiner's arguments, because the SIC region as disclosed in Marty, et al. necessarily results in a broad shallow implant profile having a tail of dopants extending through the base region of the device that reduces the device's breakdown voltage. The deficiencies of the Marty, et al. reference and the Examiner's contentions are now discussed in greater detail.

(a) The SIC region of the Marty, et al. reference comprises a tail of implant dopants that extends from the SIC region through the base and reduces the collector-base breakdown voltage of the device when forward biased, therefore failing to meet the limitation of Appellants' claimed n-type region.

Referring to Page 12 of the Examiner's Answer, the Examiner alleges that the SIC region illustrated in FIG. 6 of the Marty, et al. disclosure does not contact the base region of the device and therefore meets the limitation of Appellants' claimed n-type dopant region. Despite the illustration of the SIC region disclosed in FIG. 6 of the Marty, et al. reference, the SIC region disclosed in Marty, et al. comprises a tail of implant dopants extending through the base region of the device that reduces the device's collector-base breakdown voltage when forward biased. The tail of n-type dopants necessarily results from the Marty, et al. forming process.

Appellants' bipolar transistor comprises an n-type dopant region 18 having a vertical width (W) that is sufficiently narrow to avoid lowering the collector-base breakdown voltage and having a doping concentration sufficiently high to restrict base widening. Appellants' claimed n-type dopant region is formed by first providing an initial structure including collector 14 and subcollector 12. Next, an n-type region 18 is formed by doping the collector region 14. Following the formation of the n-type dopant region 18, the base region 26 and emitter region 34 are formed. Appellants implant the inventive n-type region 18 into the collector 14 prior to the formation of the base region 26. Referring to Page 3, lines 21-24, and FIGS. 2A-2C of the specification, Appellants disclose that the inventive n-type region 18 is formed using a low-energy, medium-dose n-type dopant implant after formation of the sub-collector region 12, and prior to the formation of the base 26, to create a very narrow, medium-dose spike (n-type region 18) in the low-doped collector region 4 of a high-voltage heterojunction bipolar transistor.

The Examiner alleges that the SIC region illustrated in FIG. 6 of the Marty, et al. disclosure meets the limitation of Appellants' n-type dopant region, since the SIC region is depicted in FIG. 6 as not in direct contact with the base region of the device. It is the

Examiner's position that since the SIC region as illustrated in FIG. 6 is not in direct contact with the base region of the device, that the SIC disclosed in Marty, et al. has a vertical width that is sufficiently narrow to avoid lowering collector-base breakdown voltage when the base-junction is forward biased. Contrary to the illustration of the SIC region depicted in FIG. 6 of the Marty, et al. reference, Appellants OBSERVE that the SIC region formed using the methods disclosed in Marty, et al. results in a broad shallow profile that necessarily includes a pronounced tail of n-type dopants contacting and extending from the collector 4 into the base region 80, 81, 82 and therefore produces an n-type dopant region that does not avoid lowering base collector breakdown voltage when the device is forward biased. The formation of the SIC region, as disclosed in Marty, et al. is now discussed in greater detail.

Marty, et al. disclose a bipolar transistor including an overdoped selectively implanted collector (SIC) region, where the SIC region is formed by a process requiring a high-energy implant and a light (high-diffusivity) ion, such as phosphorus. *See* Col. 3, line 66. The high implant energy and light ion are required in the prior art to produce the SIC region, since the SIC region is formed by implanting the light (high-diffusivity) ion into the collector 4 through the base region 80, 81, 82 of the transistor.

Appellants submit that a broad shallow profile of the SIC region results from the combination of the light (high-diffusivity) dopant ion and high-energy implant necessary to implant SIC dopants through the base region 80, 81, 82, as disclosed in Marty, et al. Subsequent spreading of the highly mobile light ion during high temperature processing forms a broad shallow implant profile, as opposed to Appellants' n-type region having a narrow vertical width (W). Appellants further submit that a tail of n-type dopants is necessarily present in the prior art transistor extending from the SIC region into the base 80, 81, 82. Appellants note that the SIC region depicted in FIG. 6 of the Marty, et al. reference represents the highest dopant concentration of the collector and does not have the structural boundaries that the Examiner is relying on to support the proposition that that the SIC region does not contact the base region of the device. Instead, a tail of SIC implant dopants extends from the SIC region through the base region 80, 81, 82 of the device. Despite not depicted

in the drawings provided in Marty, et al. disclosure, the tail of n-type dopants is present, since the SIC region is formed by implanting the high-diffusivity n-type dopants through the base 80, 81, 82 into the collector 4. Therefore, since the SIC region disclosed in Marty, et al. has a broad shallow dopant profile that necessarily includes a tail of n-type dopants contacting the base 80, 81, 82, Marty, et al. fail to disclose an n-type dopant region having a vertical width sufficiently narrow to avoid lowering collector-base breakdown voltage when the device is forward biased.

Appellants submit that the inconsistency of the SIC profile, as illustrated in FIG. 6, and the true dopant profile that necessarily results from the of Marty, et al. disclosure is similar to the facts heard by the U.S. Supreme Court in *Seymour v. Osborne*, 78 U.S. 516 (1870). In *Seymour v. Osborne* the court found that a prior art disclosure did not anticipate the claims at issue, since the disclosure of that prior art including the referenced figures were not sufficient to enable one skilled in the art to understand the nature and operation of the invention and to carry it into particular use. In *Seymour v. Osborne*, the subject of the patents at issue was mechanical farm equipment, wherein the inventive structure included two bearings on one side of a post, but no bearing on the other side. Despite that the drawings from the prior art depicted that there where two bearings on one side of the post, the courts supported the conclusion that the illustration did not suggest the invention because one skilled in the art would interpret the post to have bearings on the other side of the post as well. The court continued:

> Inventions cannot be superceded by the mere introduction of (prior art)[foreign publication] though of prior date, unless the description and the drawings contain and exhibit a substantial representation of the patented improvement, in such full, clear and exact terms as to enable any person representation of the patented improvement, in such full clear and exact terms as to enable any person skilled in the art to which it appertains to make, construct and practice the invention …… *See Seymour v. Osborne*, 78 U.S. at 555.

Similar to the facts heard by the Court in *Seymour v. Osborne* the illustration of the SIC region depicted in FIG. 6, although depicting a dopant region that does not contact the base region of the device, does not suggest to one skilled in the art Appellants' claimed n-

type dopant region having an n-type dopant region with a vertical width sufficiently narrow to avoid reducing collector base breakdown voltage. As discussed above AND, opposite Appellants' claimed method, the SIC region disclosed in Marty, et al. is formed by implanting the collector following the formation of the base region and therefore through the base region of the device. This series of process steps necessary results in a broad dopant profile and a tail of dopants, which contacts and extends through the base region of the device. Marty, et al. do not disclose any alternative methods for providing the SIC region. Therefore, despite the illustration of the SIC region depicted in FIG. 6, Marty, et al. fail to provide a substantial representation of Appellants' n-type dopant region, in such full, clear and exact terms as to enable any person representation of the patented improvement, in such full clear and exact terms as to provide appellants' invention.

The SIC region disclosed in Marty, et al. comprises a broad shallow dopant profile having a tail of dopants extending through the base region of the device and therefore fails to disclose Appellants' claimed n-type dopant region having a vertical width sufficiently narrow to avoid lowering collector base voltage.

(b) The term "Selectively Implanted Collector (SIC)" does not denote that SIC region dopants can be implanted through the base region into the collector of the device to provide Appellants' n-type dopant region that reduces collector base breakdown voltage when the device is forward biased.

Referring to Page 13 of the Examiner's Answer, the Examiner argues that the vertical height of the SIC region disclosed in the Marty, et al. reference may be adjusted, since Marty, et al. allegedly disclose that the SIC doping can be carried out *selectively*. Despite doping the SIC region into the collector region of the device through the device's base region, the Examiner alleges that the height of the SIC region may be adjusted to provide Appellants' claimed n-type dopant region having a vertical width sufficiently narrow to avoid lowering the collector base breakdown voltage when the device is forward biased. Referring to Column 3, lines 65-67, and Column 4, lines 1-5, the portion of Marty, et al. cited by the Examiner, Marty, et al. disclose that "selective overdoping of the collector

under the window of the emitter can be carried out in one or more implantation steps, thus contributing to an increase in the speed of the transistor by reducing the resistance of the collector".

Appellants submit that the term "selective" when interpreted in proper context with the complete disclosure of Marty, et al. denotes that a window 800 formed through the emitter functions as a mask during phosphorus implantation to form the SIC region in an intrinsic collector region 4. This window 800 restricts the *horizontal width* in which the dopant is introduced; it has no affect on the *vertical width* of the SIC region. As discussed above, Marty, et al. fail to disclose containing the high-diffusivity ion, implanted during the formation of the broad shallow SIC region, to a vertical width sufficiently narrow to avoid lowering collector base breakdown voltage.

Appellants submit that it is the combination of the high-diffusivity dopant and the high implant energy required by the process disclosed in Marty, et al. to implant the high-diffusivity SIC dopant through the base region 80, 81, 82 of the prior art device, which results in an n-type SIC region having a broad shallow profile and a tail of n-type dopants extending into the base region 80, 81, 82.

Appellants further submit that although the implant energy and the dopant can be modified, process conditions that result in an acceptably functioning device will still result in an implant region having a tail of dopants extending through the layers through which the dopant is implanted. The implant energy required to implant through the base region of the device without producing a tail of dopants through the base region would disadvantageously destroy the base region of the device, therefore resulting in non-operable transistor. Implanting a low diffusivity heavier dopant at the implant energies and concentrations disclosed in Marty, et al. through the base region would disadvantageously destroy the base region. There is no suggestion to modify a prior art device where the modification would render the device inoperable for its intended purpose. *In re Gordon,* 733 F.2d 900, 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984. Therefore, in order for Marty, et al. to produce a functioning transistor, Marty, et al. must use a high diffusivity dopant and an implant energy

that produces a tail of n-type dopants extending through the base region to a broad shallow SIC dopant profile in the collector.

The tail of n-type dopants extending into the p-type base and the portion of the broad shallow n-type SIC region contacting the p-type base provide PN junctions of the Marty, et al. device produce large electric fields when the transistor is forward biased. The high electric fields produced by these PN junctions accelerate the charge carriers of the transistor disclosed in Marty, et al. As the charge carriers are accelerated, they collide with lattice ions creating additional charge carriers, which may impart additional charge carriers creating an avalanche effect that destroys the device' switching nature, which in turn lowers the breakdown voltage of the device.

Applying a forward bias to the transistor disclosed in Marty, et al. creates high electric fields at the PN junctions produced where the p-type base contacts the tail of n-type dopants and the broad shallow dopant profile of the n-type SIC region, wherein the high electric fields lower the breakdown voltage of the Marty, et al. transistor. Marty, et al. fail to produce a transistor that avoids lowering collector-base breakdown voltage, and therefore fail to disclose Appellants' claimed n-type region.

Therefore, the term "Selectively Implanted Collector (SIC)" does not denote that SIC region dopants can be implanted through the base region into the collector of the device to provide Appellants' n-type dopant region having a vertical width sufficiently narrow to reduce the device's collector base breakdown voltage when the device is forward biased.

(c) It is not obvious to one of ordinary skill in the art to adjust the height of the SIC region in the Marty, et al. device to adjust the resistivity of the collector.

Referring to Page 13 of the Examiner's Answer, the Examiner alleges that it would have been obvious to one of ordinary skill in the art to adjust the height of the SIC region disclosed in Marty, et al. in order to adjust the resistance of the collector region. Appellants submit that Marty, et al., do not disclose that the resistance of the collector region may be

adjusted by adjusting the vertical height of the SIC region. The law requires that the prior art reference provide some teaching, suggestion or motivation to make the modification.

Here, there is no motivation provided in the disclosure of Marty, et al. to adjust the height of the SIC region to provide an n-type doping region having vertical width sufficiently narrow to avoid lowering the collector-base breakdown voltage when the base-junction is forward biased. The only disclosure regarding the formation of the SIC region and reducing the resistance of the collector is found in Col. 3, lines 65-67, and Col. 4, lines 1-5, of Marty, et al., in which Marty, et al. disclose that "selective overdoping of the collector (selective implantation collector) under the window of the emitter can be carried out in one or more implantation steps, thus contributing to an increased speed of the transistor by reducing the resistance of the collector." Appellants note that Marty, et al. make no reference to adjusting the height of the SIC region. "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Fitch*, 972 F.2d 1260, 1266 23 U.S.P.Q. F.2d 1780, 1783-84 (Fed. Cir. 1992).

In addition, contrary to providing motivation to provide Appellants' claimed n-type dopant region, Appellants submit that Marty, et al. teach away from Appellants' claimed invention. A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore and Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983).

Marty, et al. disclose overdoping the collector region to delay the onset of the Kirk effect at the expense of reducing the breakdown voltage of the device, similar to the prior art disclosed in the Background of Invention section of Appellants' specification. Referring to Col. 4, lines 1-5, of the Marty, et al. disclosure, the SIC region formed is *overdoped* by one or more implant steps in an effort to increase the switching speed of the device by implanting additional charge carriers. Marty, et al. disclose implanting phosphorus into the collector of the transistor to increase the switching speed of the device without providing any instruction for avoiding a reduction in the breakdown voltage.

Breakdown occurs when the additional carriers create an electric field, where the electric field accelerates the charge carriers in a manner that degrades the device's switching properties. By overdopping the collector with additional charge carriers, Marty, et al. are compromising the breakdown voltage of the device in order to increase the switching speed by offsetting the Kirk effect. Therefore, since Marty, et al. disclose overdoping the collector without providing a means to control the breakdown voltage, Marty, et al. do not provide a transistor that simultaneously avoids lowering collector-base breakdown voltage and restricts base widening when the transistor is forward biased.

Appellants disclose that in conventional semiconductor device processing, there is a tradeoff between the Kirk effect and breakdown voltage. *See* Specification Page 2, lines 4-11. Conventional doping of the collector with an n-type dopant reduces the Kirk effect but introduces charge carriers that provide high electric fields that degrade the breakdown properties of the device.

Appellant's inventive n-type region 18 is doped heavy enough to significantly delay the onset of the Kirk effect, yet has a vertical width narrow enough to avoid creating a high-electric field of sufficient duration to degrade the breakdown characteristics of the device. Appellants submit that Marty, et al. disclose overdoping the collector region to delay the onset of the Kirk effect at the expense of reducing the breakdown voltage of the device, similar to the prior art disclosed in the Background of Invention section of the Appellants' specification.

Appellants observe that Marty, et al. disclose implanting phosphorus to increase the switching speed of the device without providing any instruction for avoiding a reduction in the breakdown voltage. There is no motivation provided in the disclosure of Marty, et al. to adjust the height of the SIC region to provide Appellants' claimed n-type region. Referring to Col. 4, lines 1-5, the SIC region formed in Marty, et al. is *overdoped* by one or more implant steps in an effort to increase switching speed of the device by implanting more charge carriers into the collector. By overdopping the collector, Marty, et al. are

compromising the breakdown voltage of the device in order to increase the switching speed by offsetting the Kirk effect.

Appellants submit that Marty, et al. as interpreted by one of ordinary skill in the art depicts a semiconducting device in which the speed of the transistor can be increased by introducing additional dopant at the expense of degrading the breakdown voltage. Therefore, Marty, et al. teach away from Appellants' claimed n-type dopant region 18 having a vertical width sufficiently narrow to avoid lowering collector-base breakdown voltage when the transistor is forward biased.

The above arguments establish that all of the claims on appeal are enabled, definite and patentable over the substantive grounds of rejection raised in the Final Rejection. Appellants therefore respectfully request that the substantive grounds used in rejecting Claims 2-45, on appeal, made by the Examiner, be reversed by the Broad of Patent Appeals and Interferences.

Respectfully submitted,

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APPENDIX

The claims on appeal for U.S. Application Serial No. 09/866,319, filed May 25, 2001

2. The method of Claim 45 wherein in said providing step (b) said vertical width of said n-type dopant region is less than about 2000 Å.

3. The method of Claim 2 wherein in said providing step (b) said vertical width of said n-type dopant region is from about 800 to about 1200 Å.

4. The method of Claim 45 wherein in said providing step (b) said n-type dopant region has a peak doping concentration and said collector has a peak doping concentration, wherein said peak doping concentration of said n-type dopant region is greater than said peak doping concentration of said collector.

5. The method of Claim 45 wherein in said providing step (c) said base has a peak doping concentration and wherein said n-type dopant region has a peak doping concentration that is lower than said peak doping concentration of said base.

6. The method of Claim 45 wherein in said providing step (b) said n-type dopant region comprises a dopant selected from the group consisting of As, Sb and P.

7. The method of Claim 6 wherein said dopant is Sb.

8. The method of Claim 6 wherein in said providing step (b) said n-type dopant region is formed by ion implantation and activation annealing.

9. The method of Claim 8 wherein said ion implantation is performed at an ion dose of from about 2E11 to about 1E13 cm^{-2} at an energy of from about 20 to about 150 keV.

10. The method of Claim 9 wherein said ion implantation is performed at an ion dose of from about 5E11 to about 5E12 cm^{-2} at an energy of from about 30 to about 50 keV.

11. The method of Claim 8 wherein said activation annealing is preformed at a temperature of about 900°C or higher for about 15 seconds or less.

12. The method of Claim 45 wherein in said forming step (c) said n-type dopant region is located adjacent the base-collector junction.

13. The method of Claim 45 wherein in said forming step (c) further comprises providing a lightly doped collector separating said n-type dopant region from said base.

14. The method of Claim 13 wherein in said forming step (c) said lightly doped collector has a vertical width of about 1000 to about 3000 Å.

15. The method of Claim 45 wherein said forming step (c) comprises forming a heterojunction.

16. The method of Claim 15 wherein said step of forming a heterojunction comprises depositing a SiGe-containing layer on said collector, said SiGe-containing layer comprising a polycrystalline region abutting a single-crystal region.

17. The method of Claim 16 wherein said forming step (d) includes forming a patterned insulator on said SiGe-containing layer, wherein said pattered insulator includes an opening that exposes a portion of said single-crystal region, and forming an emitter polysilicon on said patterned insulator and in said opening.

18. The method of Claim 17 wherein said step of forming a patterned insulator on said SiGe-containing layer comprises lithography and etching.

19. The method of Claim 16 wherein portions of said single-crystal region are doped so as to form extrinsic base regions therein.

20. The method of Claim 16 wherein said SiGe-containing layer comprises SiGeC.

21. The method of Claim 16 wherein said step of depositing a SiGe-containing layer is performed using a low-temperature deposition process selected from the group consisting of chemical vapor deposition (CVD), plasma-assisted CVD, atomic layer deposition (ALD), chemical solution deposition and ultra-high vacuum CVD.

22. The method of Claim 45 wherein said deep collector is formed by ion implantation and annealing.

23. The method of Claim 45 wherein in said providing step (a) said sub-collector is formed by ion implantation into a substrate or by epitaxially growing said sub-collector on a substrate.

24. A bipolar transistor comprising:
an emitter, a base, a collector, a base-emitter junction, and a base-collector junction, wherein said collector comprises a subcollector, a deep collector and a n-type dopant region between said sub-collector and said base-collector junction, said n-type dopant region is located atop and in contact with said deep collector and has a vertical width sufficiently narrow to avoid lowering collector-base breakdown voltage and a dopant concentration sufficiently high to restrict base widening when the base-junction is forward biased.

25. The bipolar transistor of Claim 24 wherein said n-type dopant region is located adjacent the base-collector junction.

26. The bipolar transistor of Claim 24 wherein said vertical width of said n-type dopant region is less than about 2000 Å.

27. The bipolar transistor of Claim 26 wherein said vertical width of said n-type dopant region is from about 800 to about 1200 Å.

28. The bipolar transistor of Claim 24 wherein said n-type dopant region has a peak doping concentration and said collector has a peak doping concentration, wherein said peak doping concentration of said n-type dopant region is greater than said peak doping concentration of said collector.

29. The bipolar transistor of Claim 24 wherein said base has a peak doping concentration and wherein said n-type dopant region has a peak doping concentration that is lower than said peak doping concentration of said base.

30. The bipolar transistor of Claim 24 wherein said n-type dopant region comprises a dopant selected from the group consisting of As, Sb and P.

31. The bipolar transistor of Claim 30 wherein said dopant is Sb.

32. The bipolar transistor of Claim 24 further comprising a lightly doped collector separating said n-type dopant region from said base.

33. The bipolar transistor of Claim 32 wherein said lightly doped collector has a vertical width of about 1000 to about 3000 Å.

34. The bipolar transistor of Claim 24 wherein said n-type dopant region provides a higher speed of the transistor by restricting base widening.

35. The bipolar transistor of Claim 26 wherein said sub-collector is on a semiconductor substrate.

36. The bipolar transistor of Claim 35 wherein said semiconductor substrate is a semiconducting material selected from the group consisting of Si, Ge, SiGe, GaAs, InAs, InP, Si/Si, Si/SiGe and silicon-on-insulators.

37. The bipolar transistor of Claim 24 wherein said n-type dopant region has a dopant concentration of from about 5E16 to about 5E17 cm^{-3}.

38. The bipolar transistor of Claim 24 wherein said n-type dopant region has a dopant concentration of from about 8E16 to about 2E17 cm^{-3}.

39. The bipolar transistor of Claim 24 wherein the transistor comprises a heterojunction.

40. The bipolar transistor of Claim 39 wherein said heterojunction comprises a SiGe-containing base layer on a silicon substrate.

41. The bipolar transistor of Claim 40 wherein said SiGe-containing base layer comprises a polycrystalline region abutting a single-crystal region.

42. The bipolar transistor of Claim 41, wherein said emitter comprises polycrystalline silicon contacting a portion of said single-crystal region through an opening in a patterned insulator.

43. The bipolar transistor of Claim 41 wherein said single-crystal region includes extrinsic and intrinsic base regions.

44. The bipolar transistor of Claim 40 wherein said SiGe-containing base layer comprises SiGeC.

45. A method of fabricating a bipolar device comprising the steps of:
(a) providing a structure comprising at least a sub-collector region, a collector region and isolation regions, said collector region including a deep collector region located therein;

(b) forming a n-type dopant region within said collector region so as to be in contact with said deep collector, said n-type dopant region having a vertical width sufficiently narrow to avoid lowering collector-base breakdown voltage and a dopant concentration sufficiently high to restrict base widening when a base-emitter junction is forwarded biased;

(c) forming a base; and

(d) forming an emitter.